Attivita' di Qualificazione dei Componenti Elettronici in Italia: L'Esperienza MAPRAD

Behcet ALPAT
INFN Sezione di Perugia

MAPRad

Chinese Version

MAPRad Company Profile

MAPRad s.r.l. is a recently founded company working on the field of Space and high-reliability electronics design and qualification. Although the company has a recent foundation date, it is based on the experience of more than years of work in scientific space projects of highly qualified electronics and mechanical engineers and experimental high energy physicists. The company mission is to develop electronic systems based on COTS using screening procedures, design strategies and qualification tests (radiation, MTTF, environmental tests) to enhance the reliability of the electronic system itself. In addition, thanks to close cooperation with partner companies MAPRad offers also qualification tests to military (i.e. MIL-STD 810) and industrial standards for mechanical (vibration, acceleration and shock) and thermovacuum tests of parts or systems.

We provide the following services:

- Radiation hardness qualification and reliability studies (Radiation environment simulation, Total dose and Single Event Effect in accelerators and in laboratory)
- Radiation contamination measurement
- Component Procurement Support (Commercial, Industrial, Military or Space Qualified components)
- Failure Analysis (FMEA, FMECA)
- Environmental tests (Mechanical, Thermal, Thermo-Vacuum, EMI/EMC)
- Electronic systems design and assistance (Power Supply Systems, DAQ systems, Data Transmission Systems, Test Equipments)
- training and organization of workshop and schools on space qualification, radiation damage, space engineering

We have access to the following outsourcing facilities:

1. INFN-LNS (Catania , Italy) at superconducting Cyclotron for SEE and Displacement Damage tests with protons and heavy ions,
2. INFN-SIRAD (Legnaro,Italy) at radiation effect test facilities for SEE test with heavy ions,
3. ENEA-Calliope (Rome , Italy), Co60 gamma ray source for total dose irradiation,
4. TAEA-SANAEM (Sarayköy, Turkey), Co60 gamma ray source for total dose irradiation.

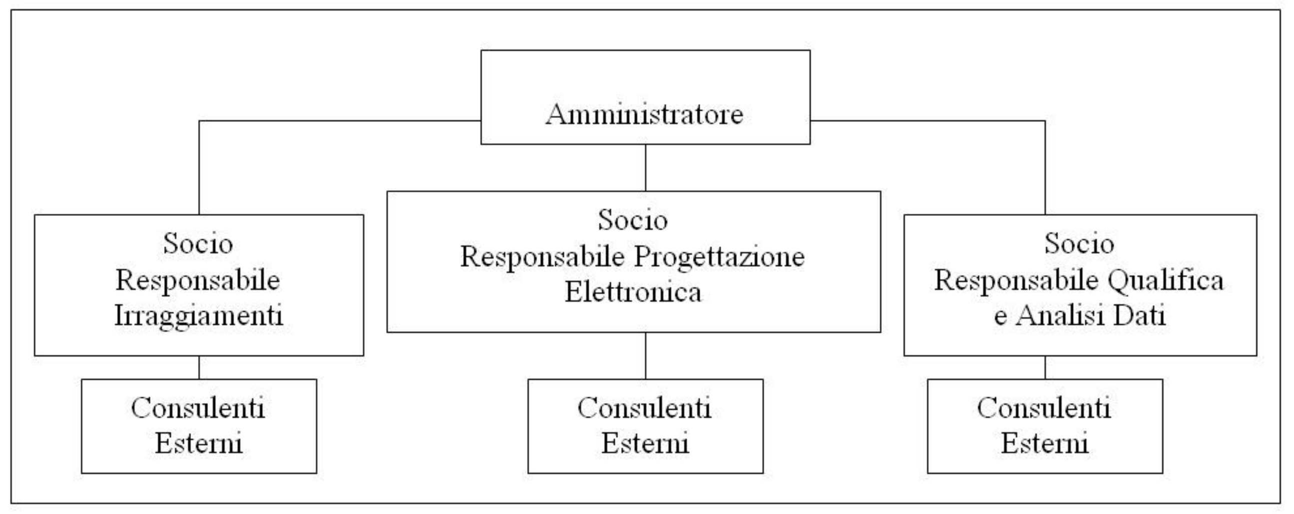
We have direct access to the following equipments:

1. Laser test system for SEE tests.
2. X-ray machine for Total dose tests.
3. Thermal chamber for thermal tests burn-in and MTTF studies
4. Shaker and Space Simulator for Vibration and Thermo-Vacuum Tests

MAPRad srl

MAPRad s.r.l. is a recently founded company working on the field of Space and high-reliability electronics design and qualification.

Although the company has a recent foundation date, it is based on the experience of more than years of work in scientific space projects of highly qualified electronics and mechanical engineers and experimental high energy physicists.



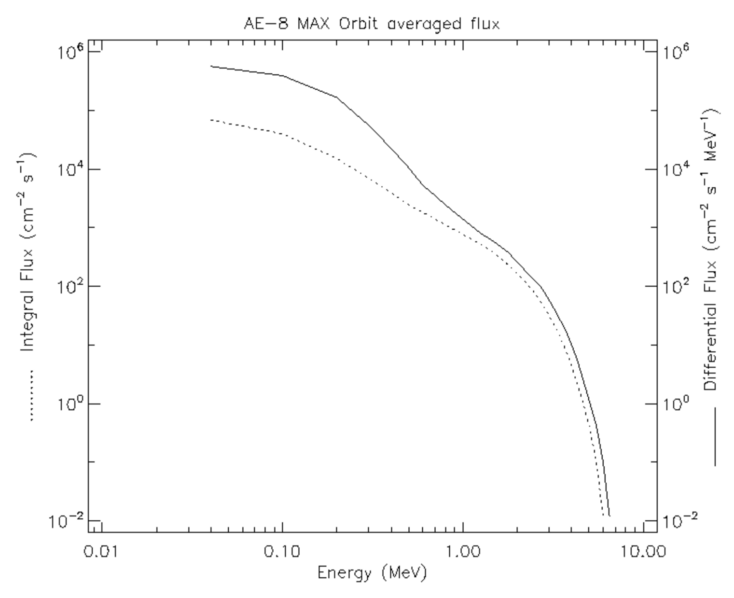
Services

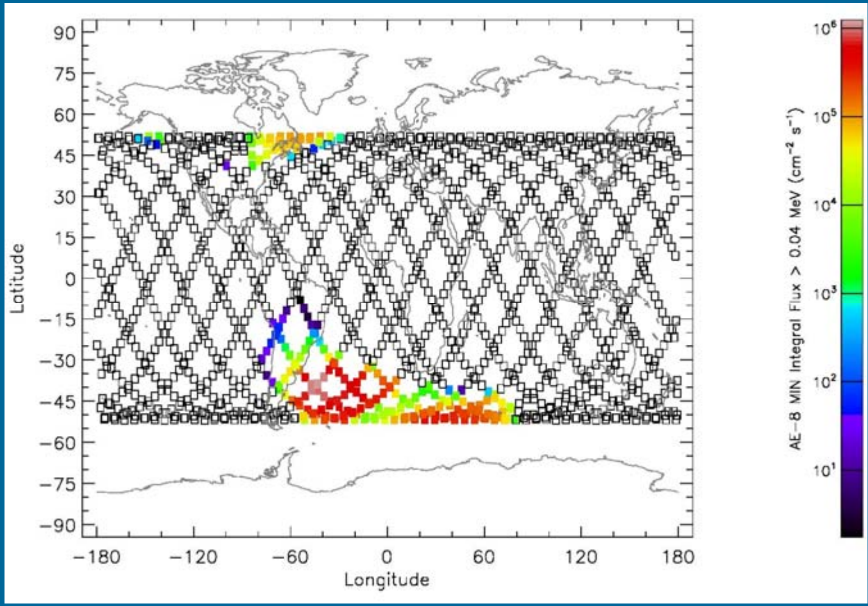
ESA Small and Medium Enterprise (ESABD 13331)

- Space Radiation Environment evaluation
- Radiation Damage Tests and CAD Modeling
- Electronic and Mechanical devices qualification (Standard Testing Methods ESA, MIL, JEDEC)
- New Concept Radiation Detector Development
- Electronic Design and Consulting
- Electronic Part Selection & Procurement
- Training and Formation

Radiation Environment Simulation (1)

- Particle fluxes simulated using ***SPENVIS, CREME96, AF-GEOSPACE***
- Effects on devices simulated using ***GEANT4, GRAS, FLUKA***
- By simulating both diffuse and location dependent contributions (like Particles Trapped by Geomagnetic field) we are able to estimate the effects on average and in the Worst Case Scenario.

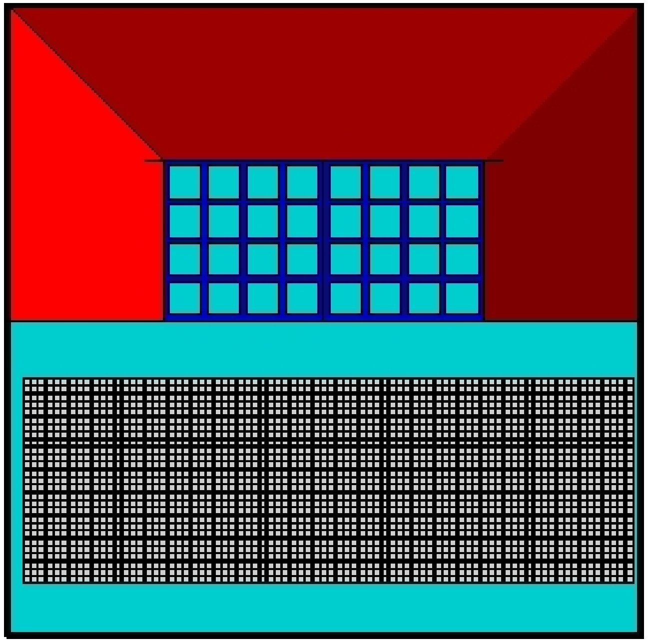


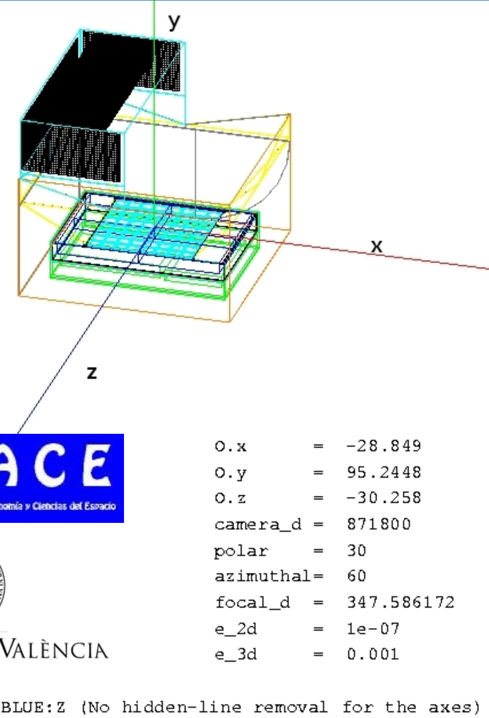


Radiation Environment Simulation (2)

- Evaluation of Background Count Rates for the ASIM Experiment http://www.dsri.dk/atmosphere/asim/

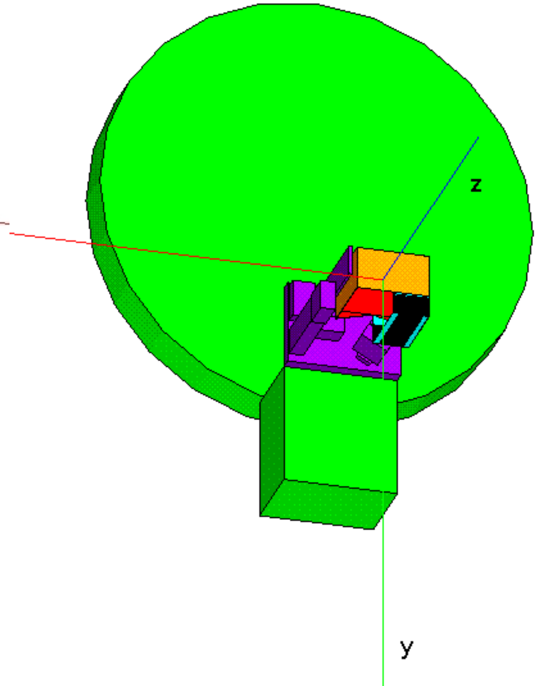
GEANT4 simulation of MXGS, ASIM's main detector.
Cosmic and Trapped Particle fluxes are studied, also taking into account:
Flux alteration due to ASIM ancillary detectors
Flux alteration due to ISS Modulus Columbus where the experiment will be attached,
Experiment materials activation and subsequent decay.
Daily modulation of fluxes along the orbit



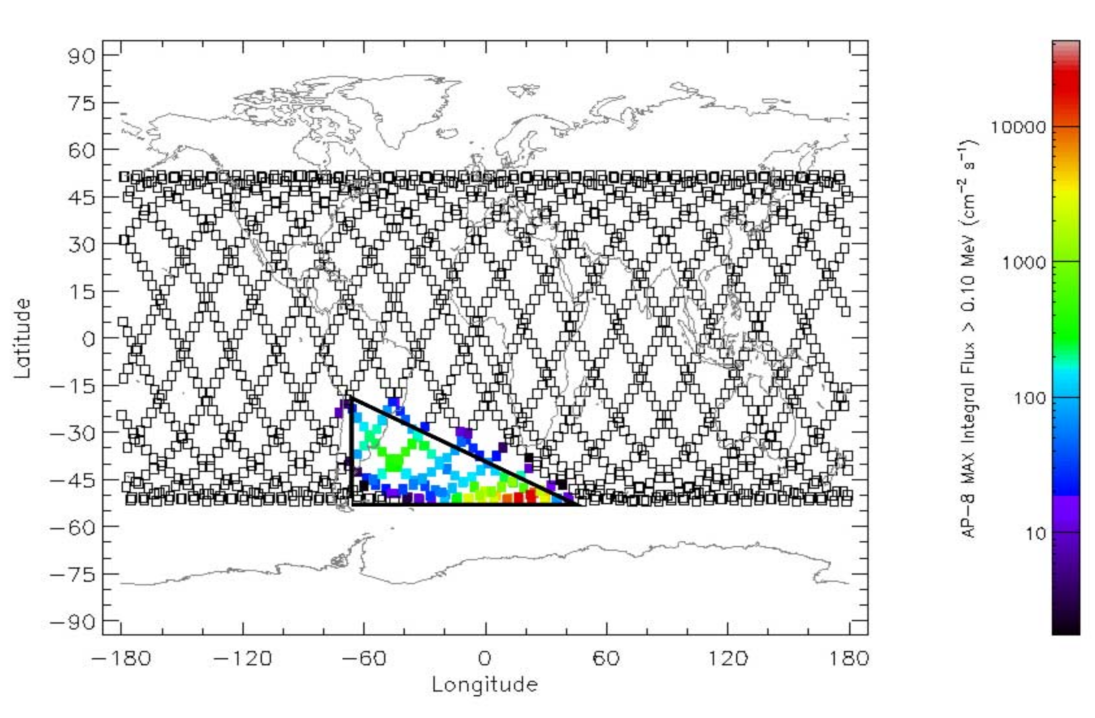


GACE Grupo de Astronomía y Ciencias del Espacio

VNIVERSITAT DE VALÈNCIA

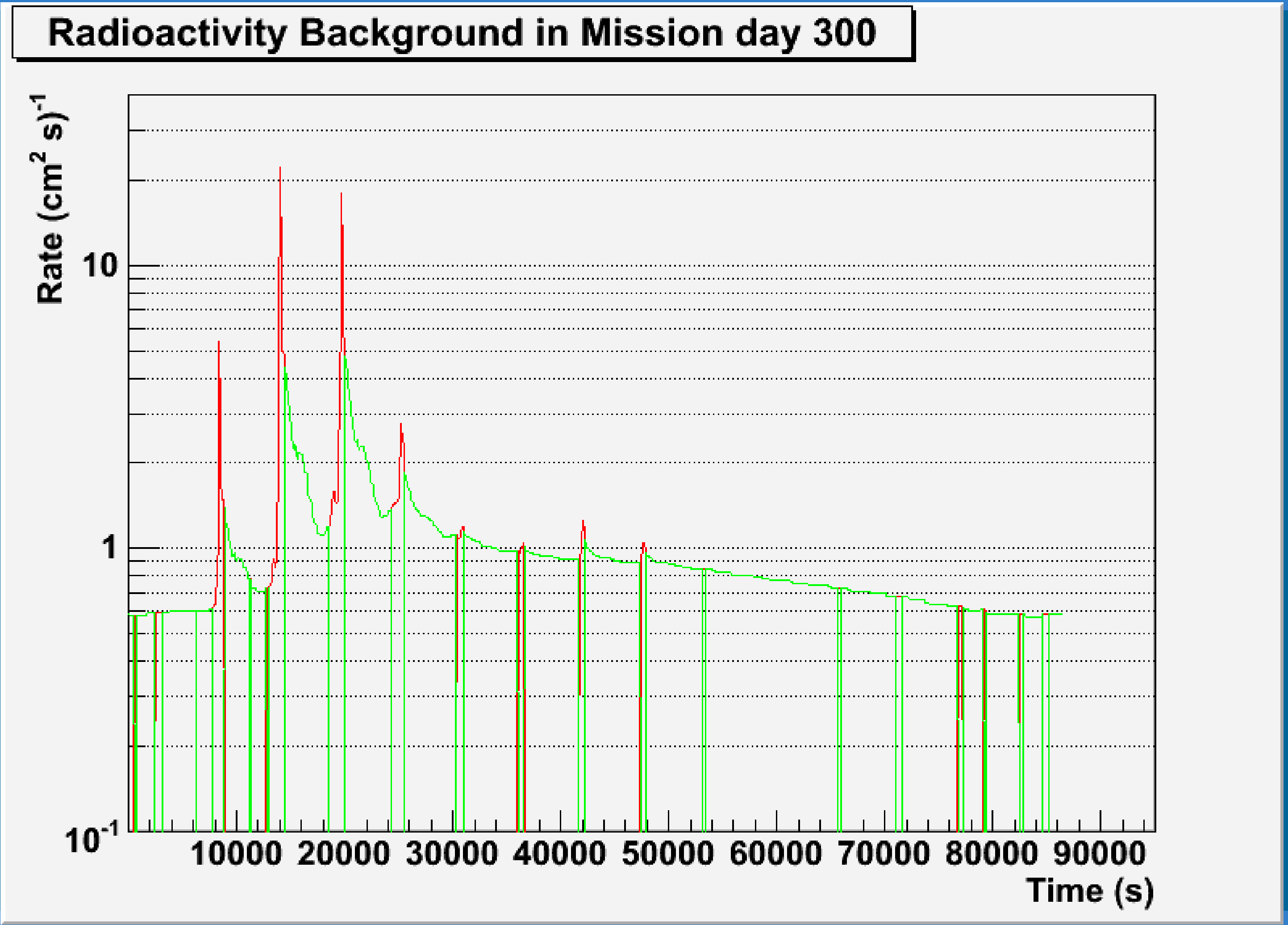


Radiation Environment Simulation (3)



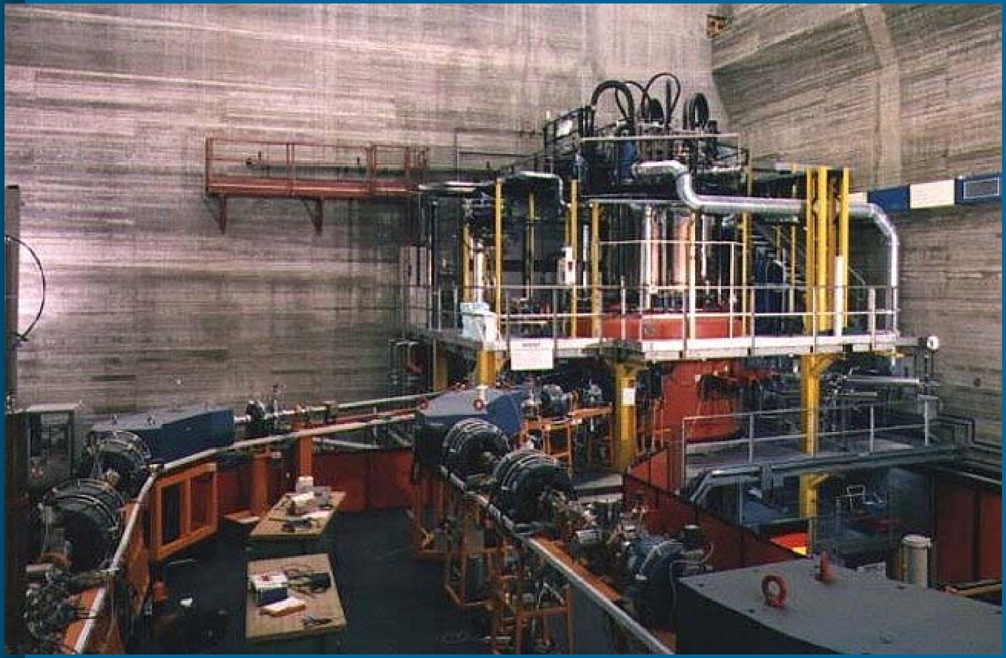
Particle Type	Total Background (part/(cm^2.s))
Trapped protons	***5,8***
Trapped protons excluding SAA	***0,06***
Trapped electrons	***7400,0***
Trapped electrons excluding SAA	***0,5***
Solar Protons	***0,12***
Atmospheric Gamma-ray	***1,5***
GCR Protons	***0,26***
GCR He	***0,043***

Radiation Environment Simulation (4)



Single Event Effects Tests at Accelerators

SEE Test: **Cyclotron at LNS** (Catania), of Italian National Institute for Nuclear Physics (INFN).



The **LNS Cyclotron** has 15 to 48 MHz RF system;

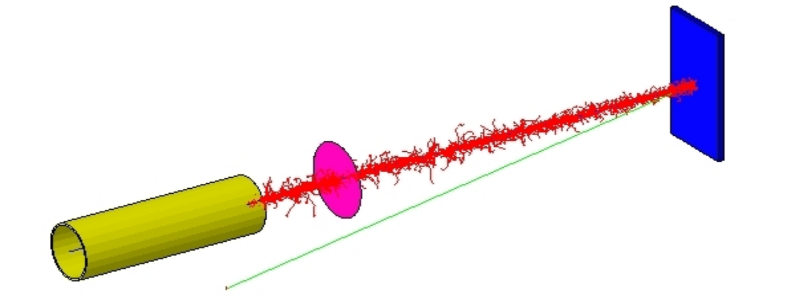
the ion energies range is between **8 and 100 A MeV** in harmonic mode h=2. The expected maximum energies of the machine are of 20 MeV/amu for the heaviest ions, like $^{238}U_{38+}$, and 100 MeV/n for fully stripped light ions

LNS Beams Used for RH Qualification Tests

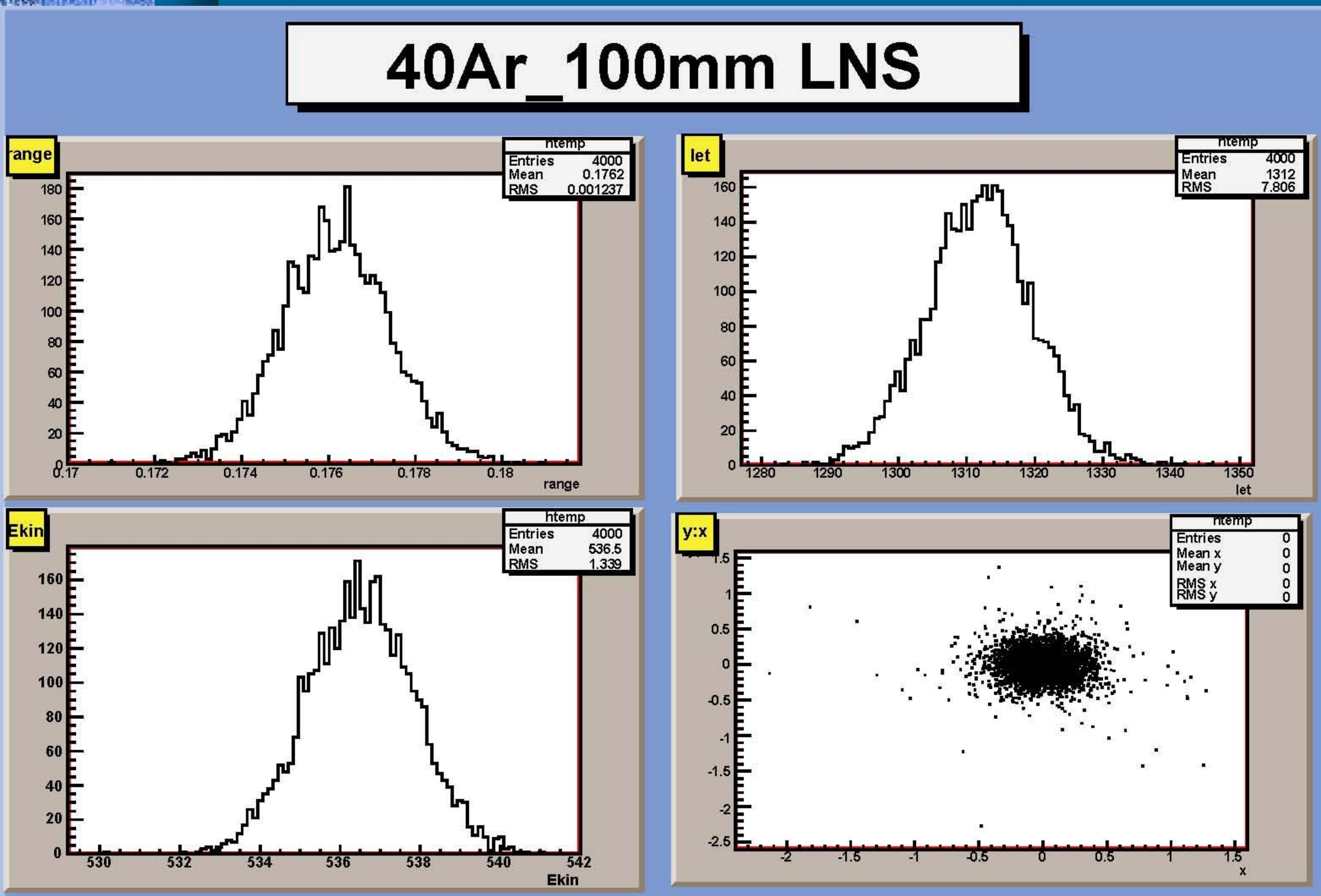
- For SEE test Gaseous Beams at 20 MeV/nucleon
  - ^{20}Ne
  - ^{40}Ar
  - ^{84}Kr
  - ^{129}Xe
- All “Contianed” Events with range in Si of 70um to 450 um
- For DD tests protons of 20-to-60 MeV

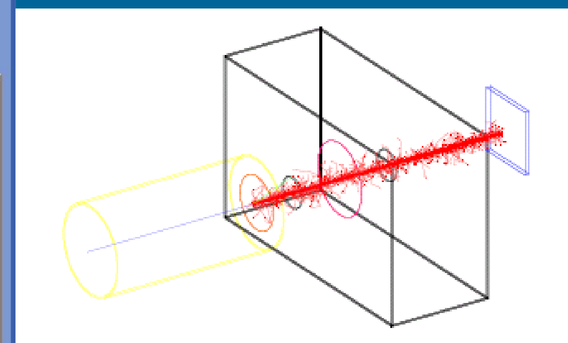
Dosimetry System Features

- Thin scintillator (50 and 100 um) is to obtain a circular beam spot and for the online fluence measurement >99 % efficiency
- Motorized stage with submicron accuracy of position repeatability (X,Y max 20 cm and Z max 30 cm). The rotator for measuremnts with theta angle up 60 degrees.
- 1.5 mm thick double sided microstrip detector with 170 um spatial resolution.
  - All the selected ions are stopping inside hence calorimetric measurements
  - To localize and measure the beam spot (3-D profile of the beam is obtained);
    - Each event is
      - time tagged with 125 ns resolution
      - Energy tagged through dE/dX measurements in silicon
- SELDP (Single Event Latchup Detector and Protector)
  - Custom module to monitor and count the SEL behaviour of DUT (wide range of DUTs are covered)
- Online Monitoring of Environmental parameters (T, RH)

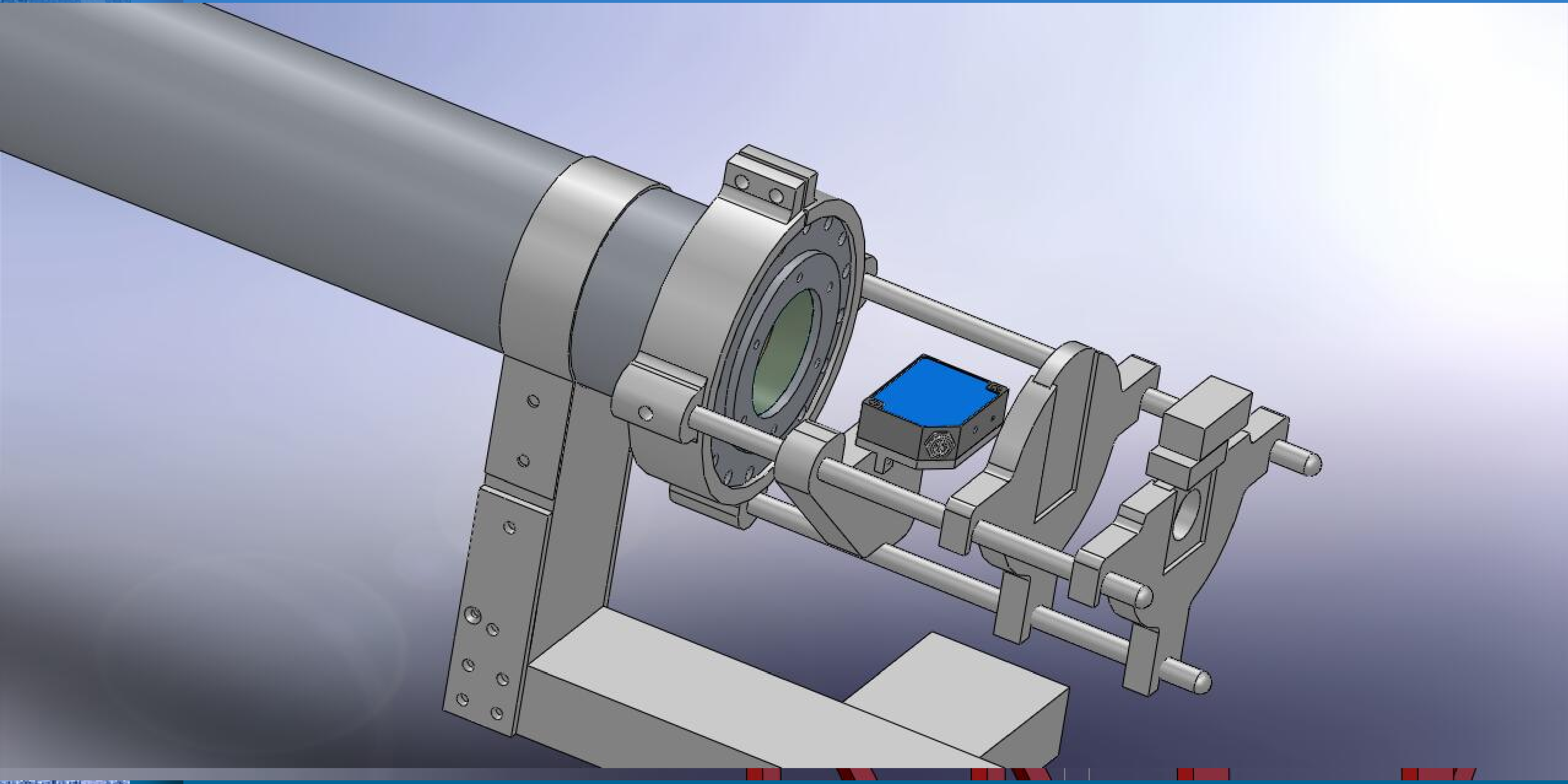


GEANT4 and FLUKA Simulations

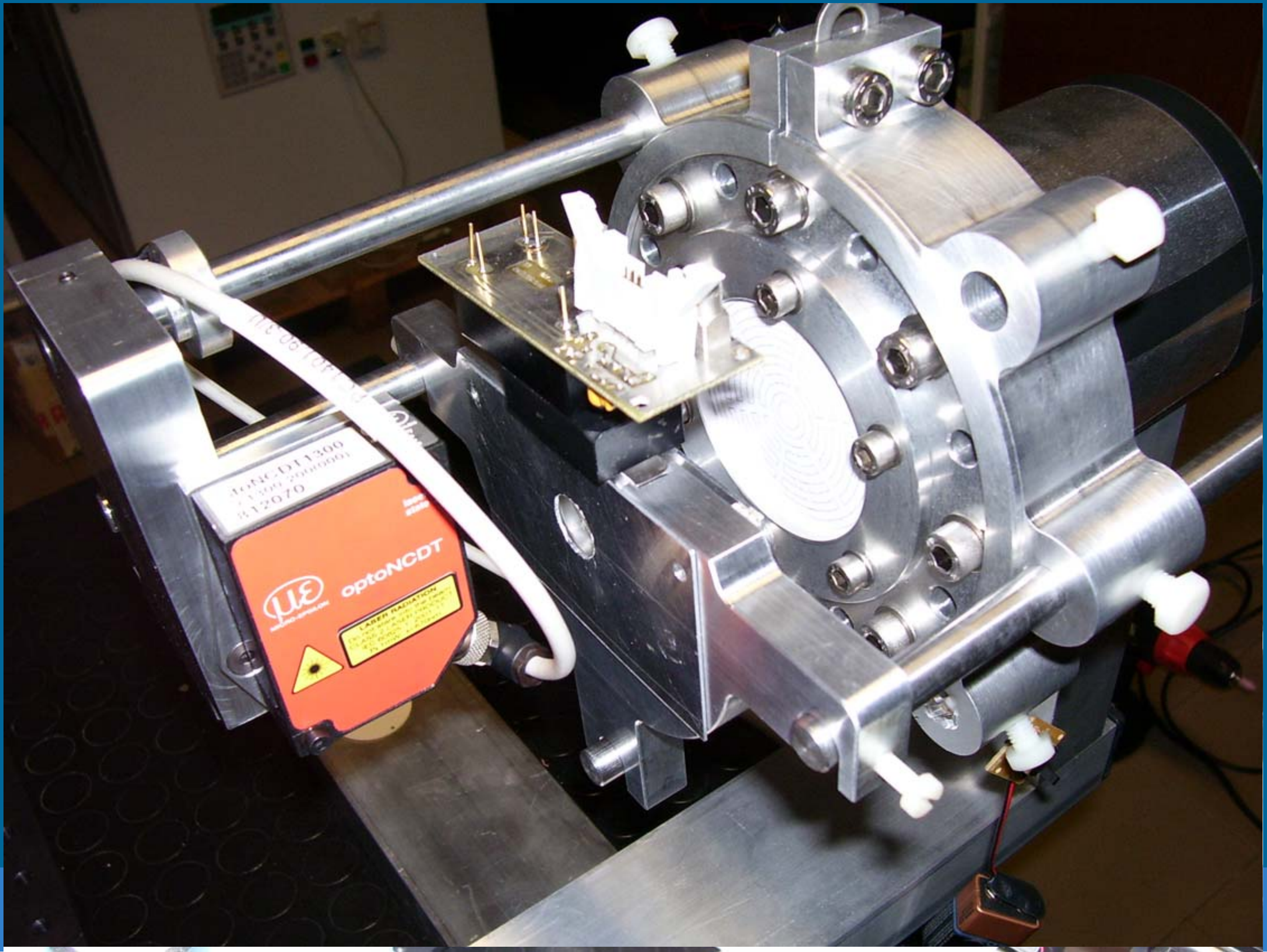




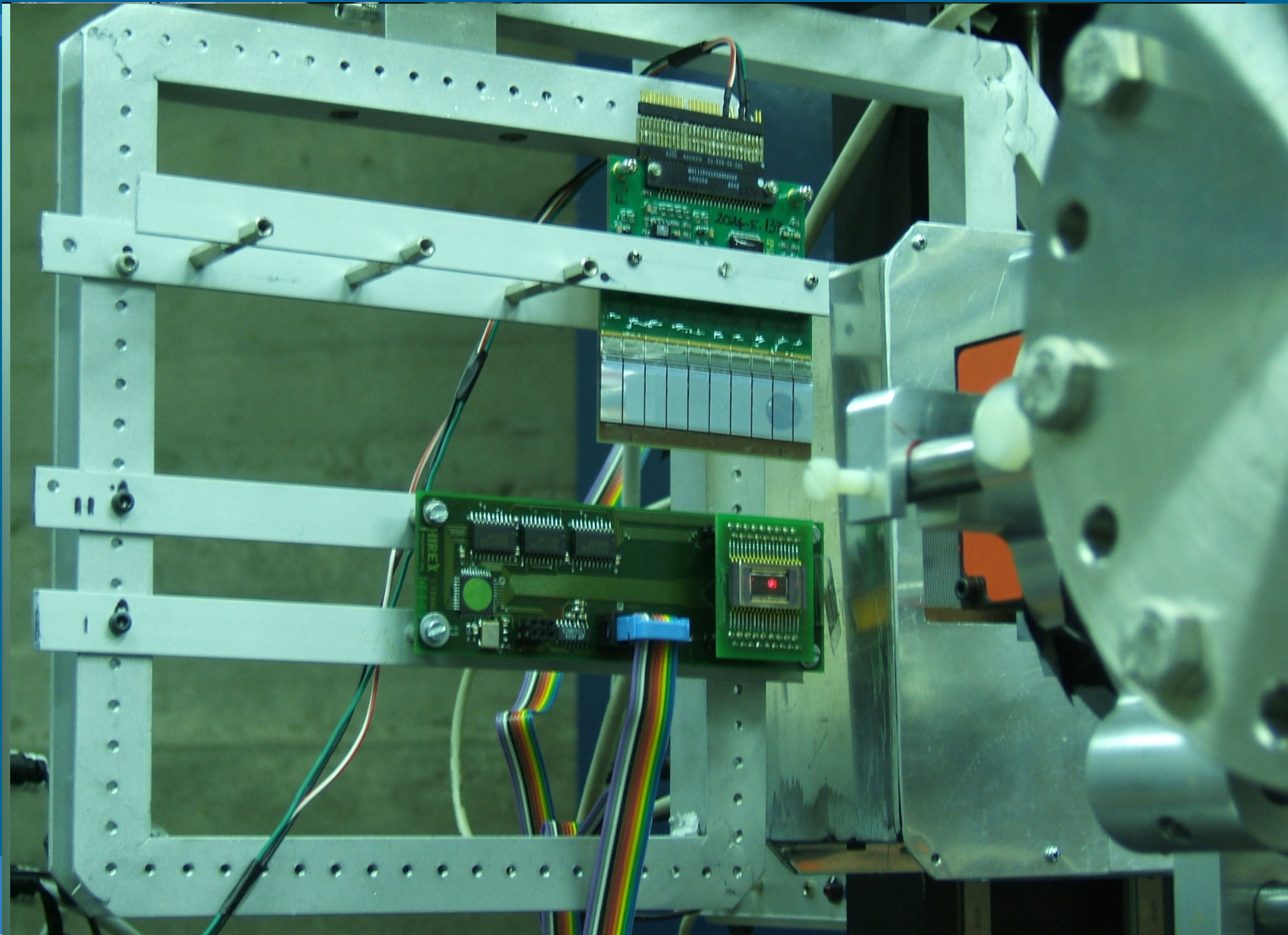
CAD design of LNS Setup



LNS Beam SETUP
Mock-up at MAPRAD labs (March 2009)



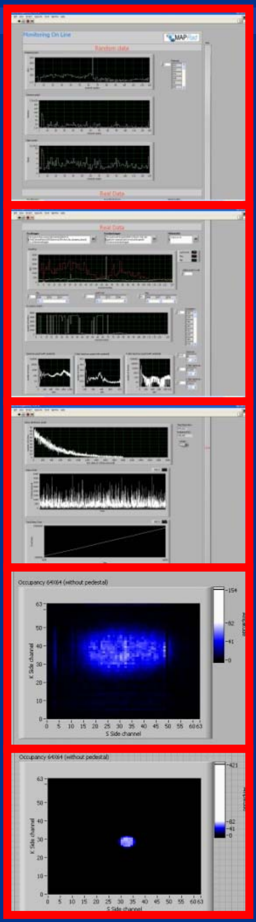
LNS Beam SETUP (April 2009)

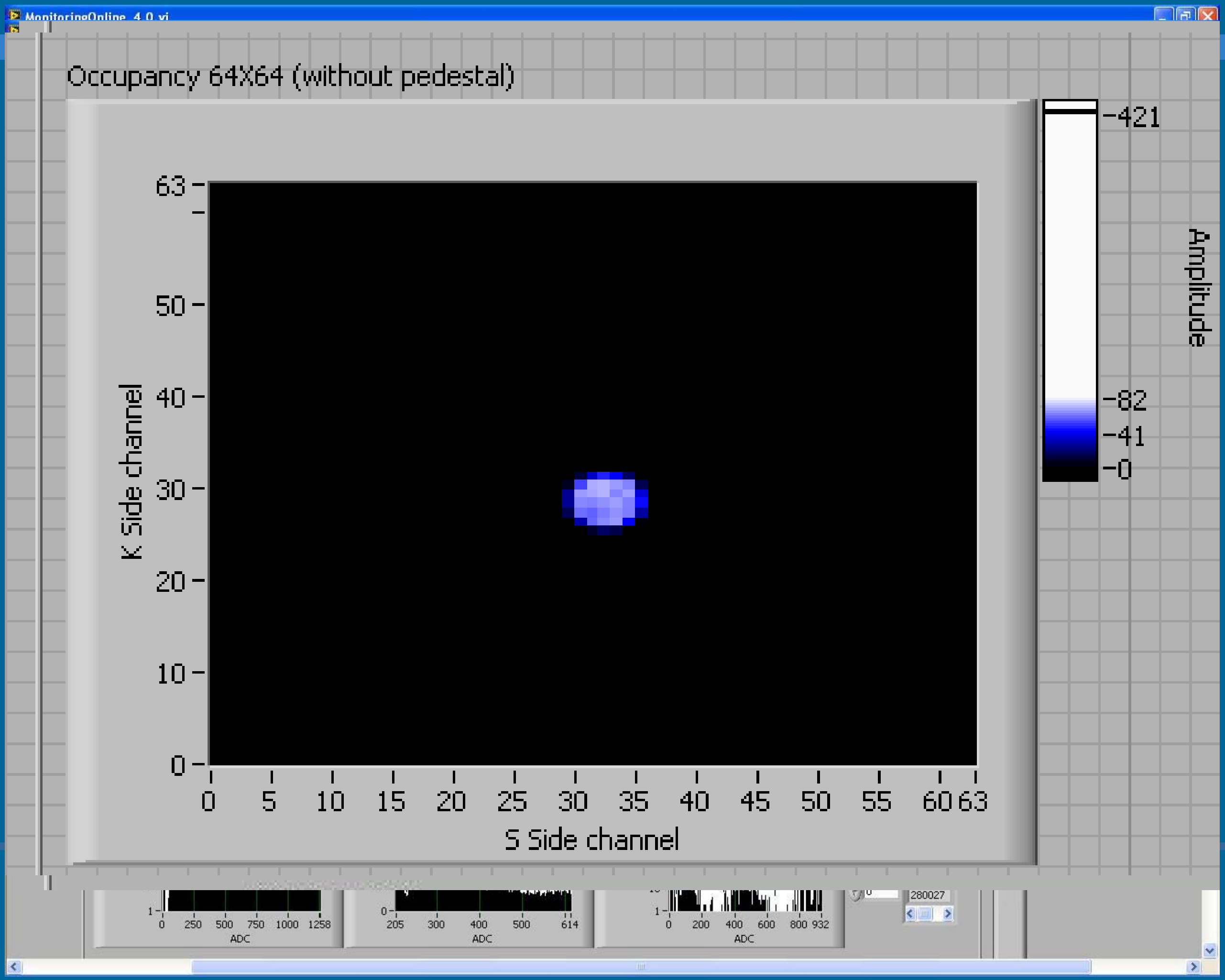


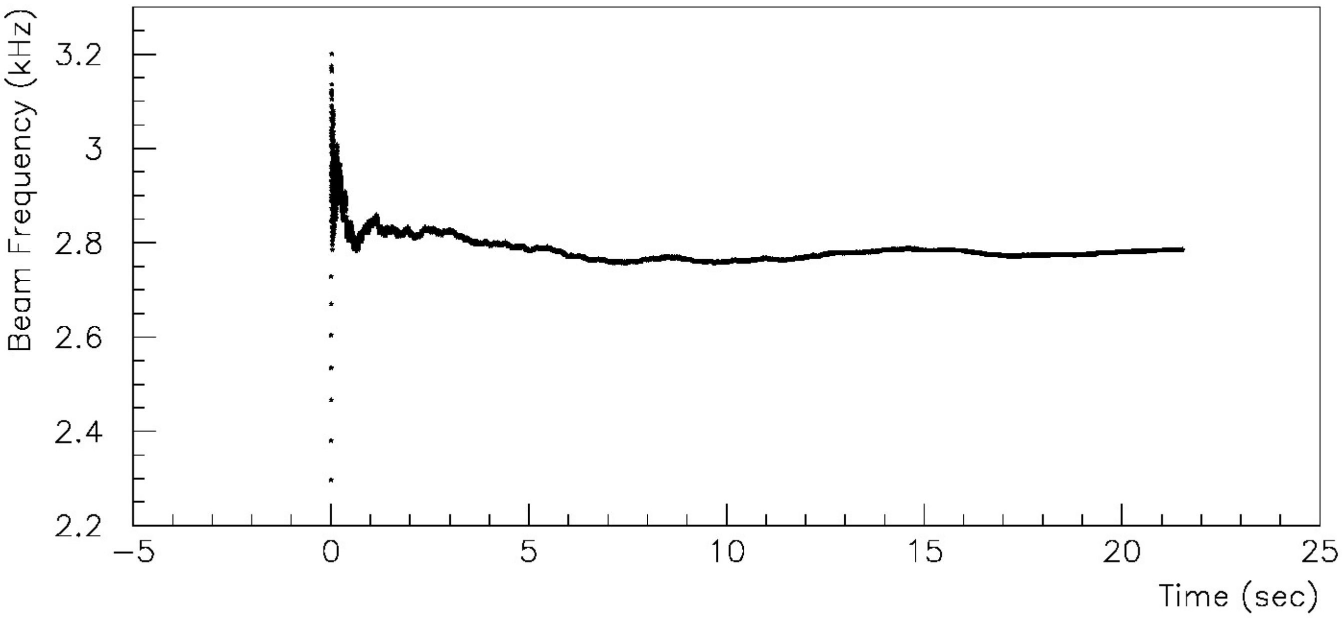
Software for Monitoring OnLine

Diviso in diverse aree:

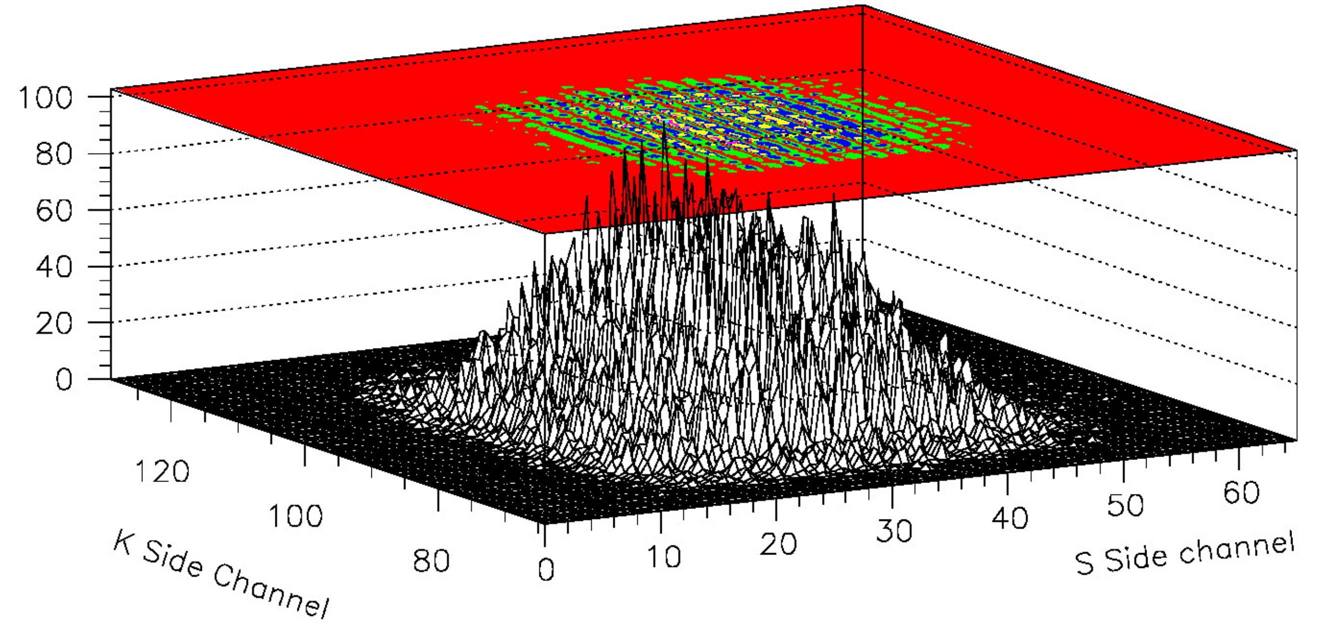
- Random data
- Real data
- Timing
- Beam profile
  - Protoni
  - Cm 244 collimata





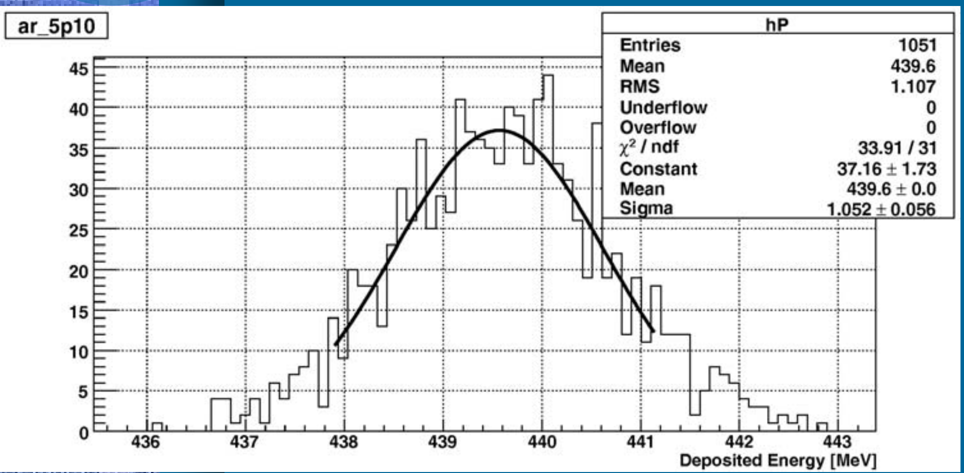


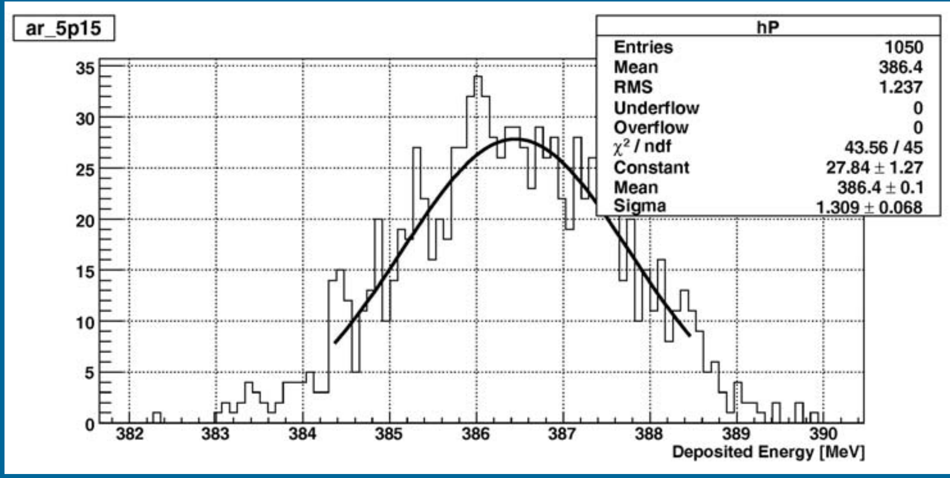
Beam Frequency (kHz)
3.2
3
2.8
2.6
2.4
2.2
−5
0
5
10
15
20
25
Time (sec)

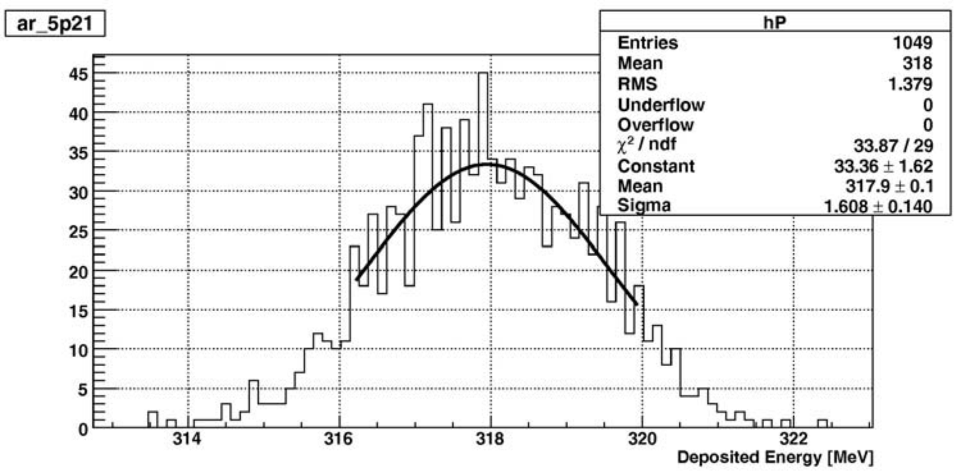


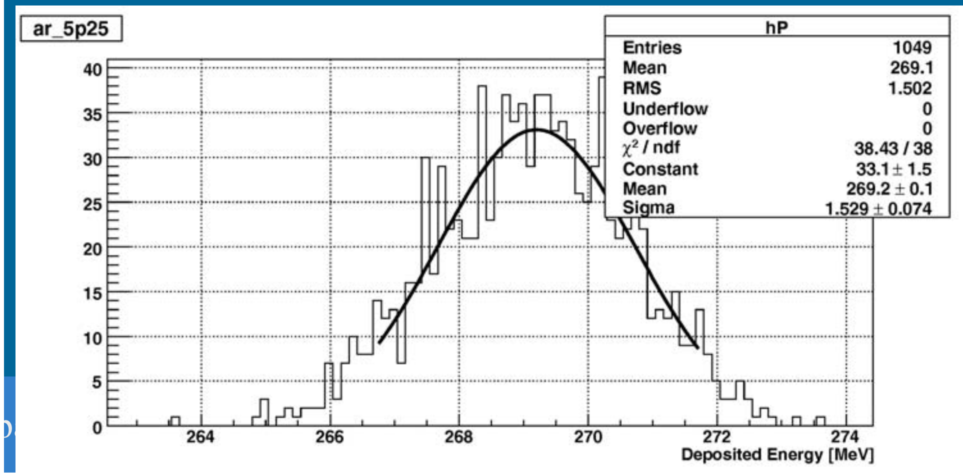
100
80
60
40
20
0
120
100
80
K Side Channel
0
10
20
30
40
50
60
S Side channel

From G4 Montecarlo, Standard Physics, Charge Distributions for ^{40}Ar, air2=10,15,20,25 cm

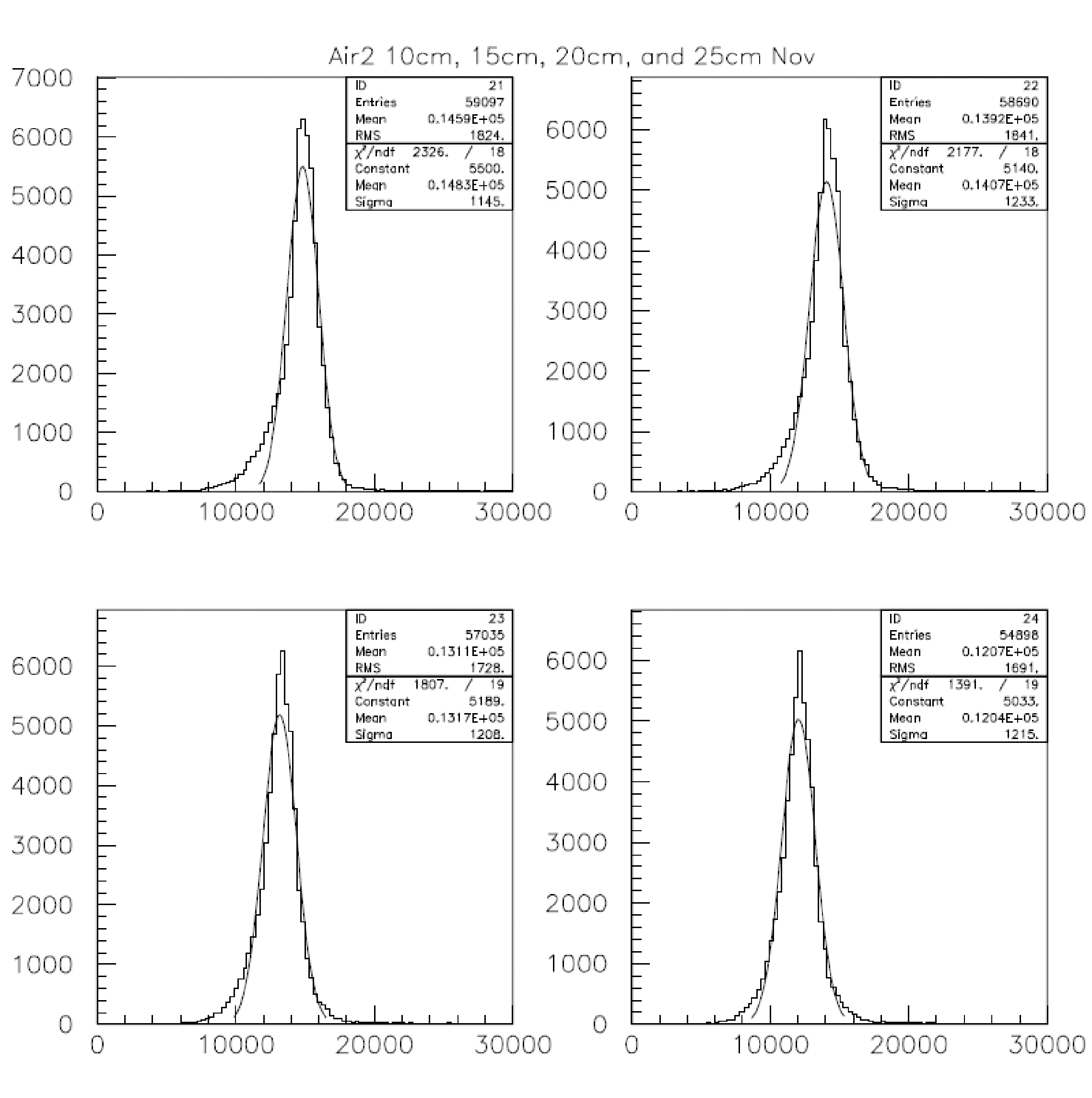




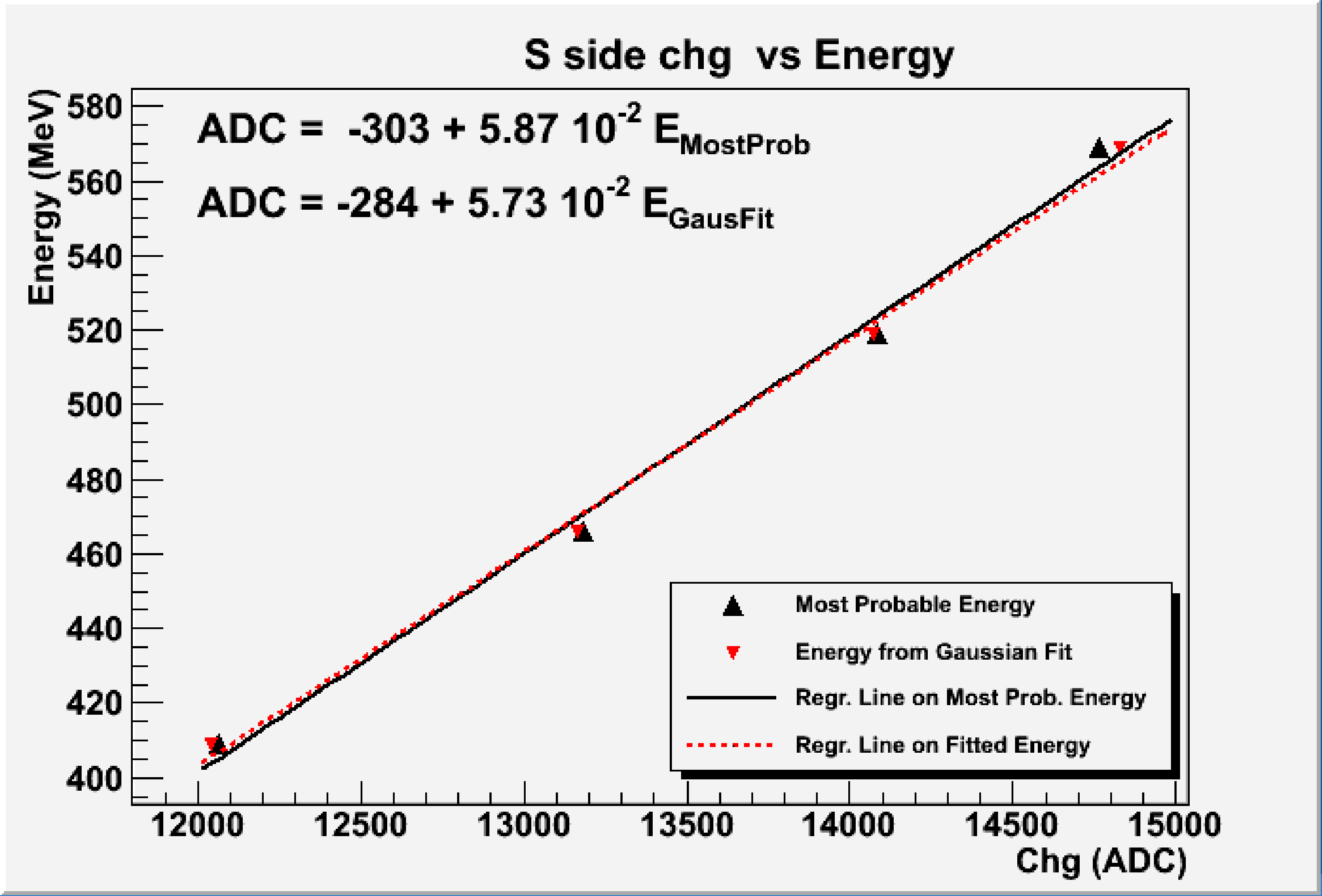




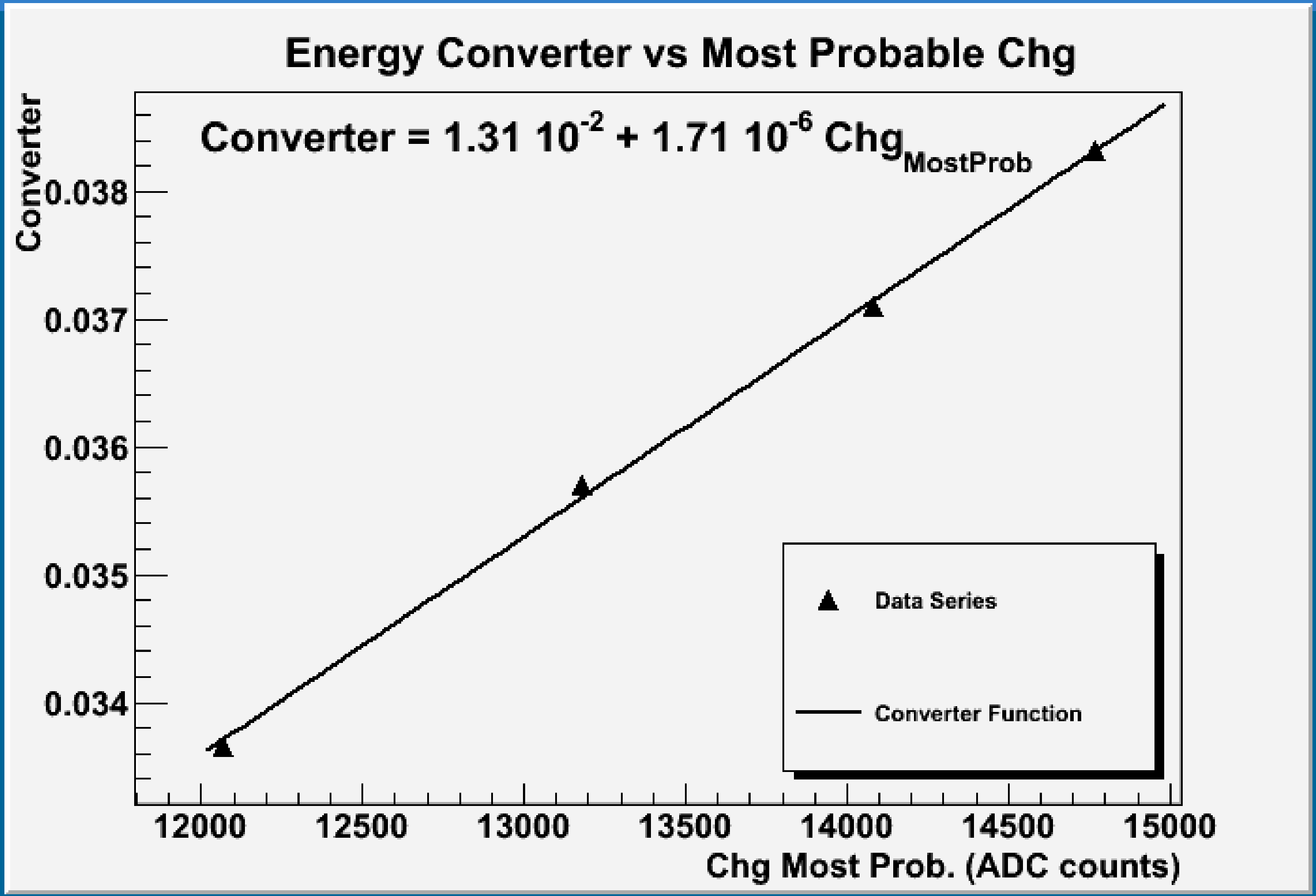
From LNS dataset, Charge Distributions for ^{40}Ar, air2=10,15,20,25



G4-to-Data/Charge-to-Energy Conversions (1)



G4-to-Data/Charge-to-Energy Conversions (2)



Error Evaluation (1)

- The systematic errors contributing to the overall error on LET and Fluence values are;
  - **Error on LET Value**
    - Distance meauserements (air thickness).
      - This is done with 200 um accuracy laser system only once during the initial calibration phase. All other positions are relative to that point with submicron precision 4-D stage (X,Y,Z, Theta)
    - Fragmentation (i.e. $<10^{-4}$ per ^{40}Ar at 15 cm air)
      - Simulations with **BinaryLightIoncascade and G4wilsonAbrasionModel**
    - Determination of energy deposited and Range in DUT
      - Deposited charge in silicon; from data
      - Deposited energy and range in silicon; from G4 simulation
      - Charge-to-Energy Conversion

Error Evaluation (2)

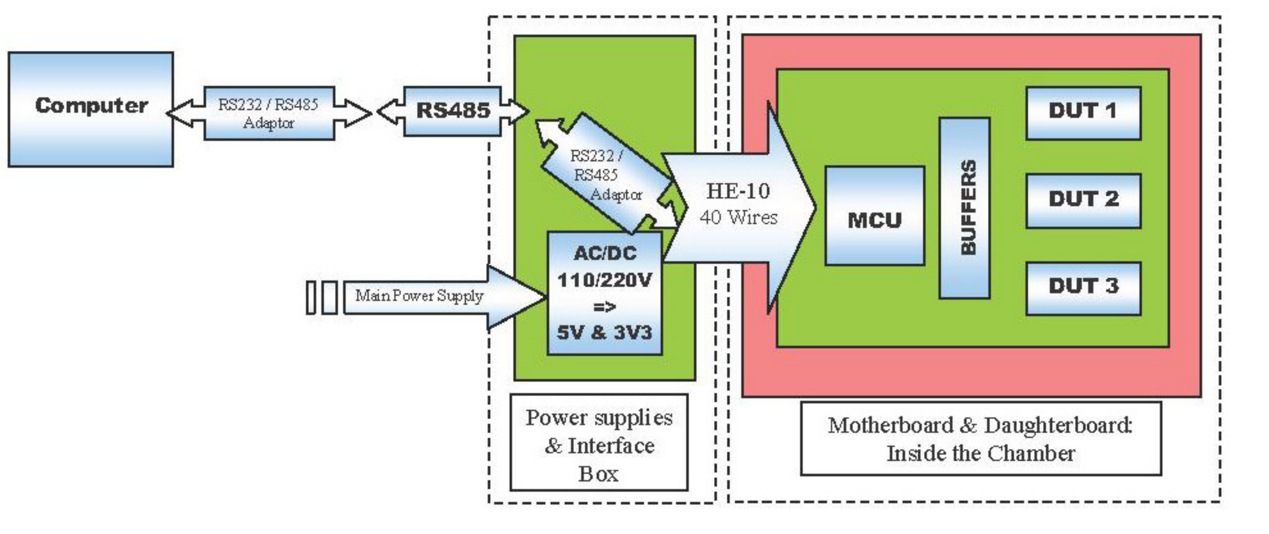
- The systematic errors contributing to the overall error on LET and Fluence values are (cnt'd);
  - **Error on Fluence Value**
    - Positioning of beam spot center to the center of DUT
      - This is done through positioning of beam spot first on double sided thick silicon with 170 um spatial resolution. Then it is shifted on to DUT center (the DUT reference crosses wrt to Silicon reference crosses are measured once during the initial calibration phase)
    - Fluence measurement from thin scintillator and from silicon detector

Overall Error Estimation on LET values

With average trigger efficiency of ~88 %

Ion/LET (MeV/mg/cm2)	Error on LET (MeV/mg/cm2)
Neon-20/3.7	0.1
Argon-40/13.13	0.2
Krypton-84/30.6	0.7
Xenon-129/52.9	0.8

SEU Monitor (ESA/ESTEC)



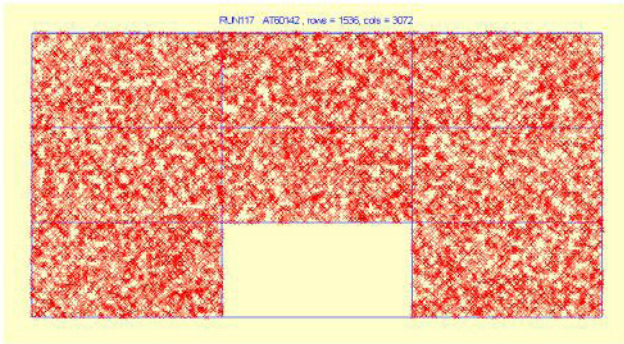


Figure 7. Physical location of SEUs - confirming uniform beam.

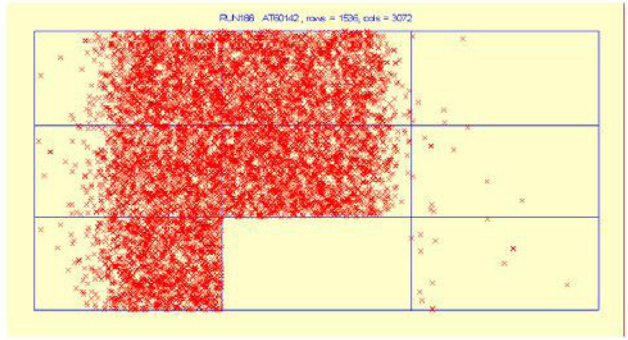


Figure 8. Physical location of SEUs – revealing a faulty beam.

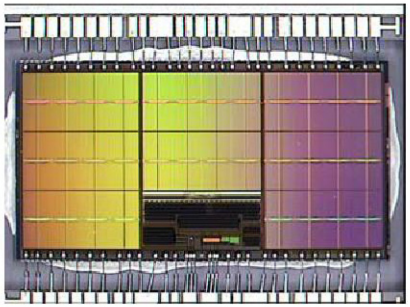
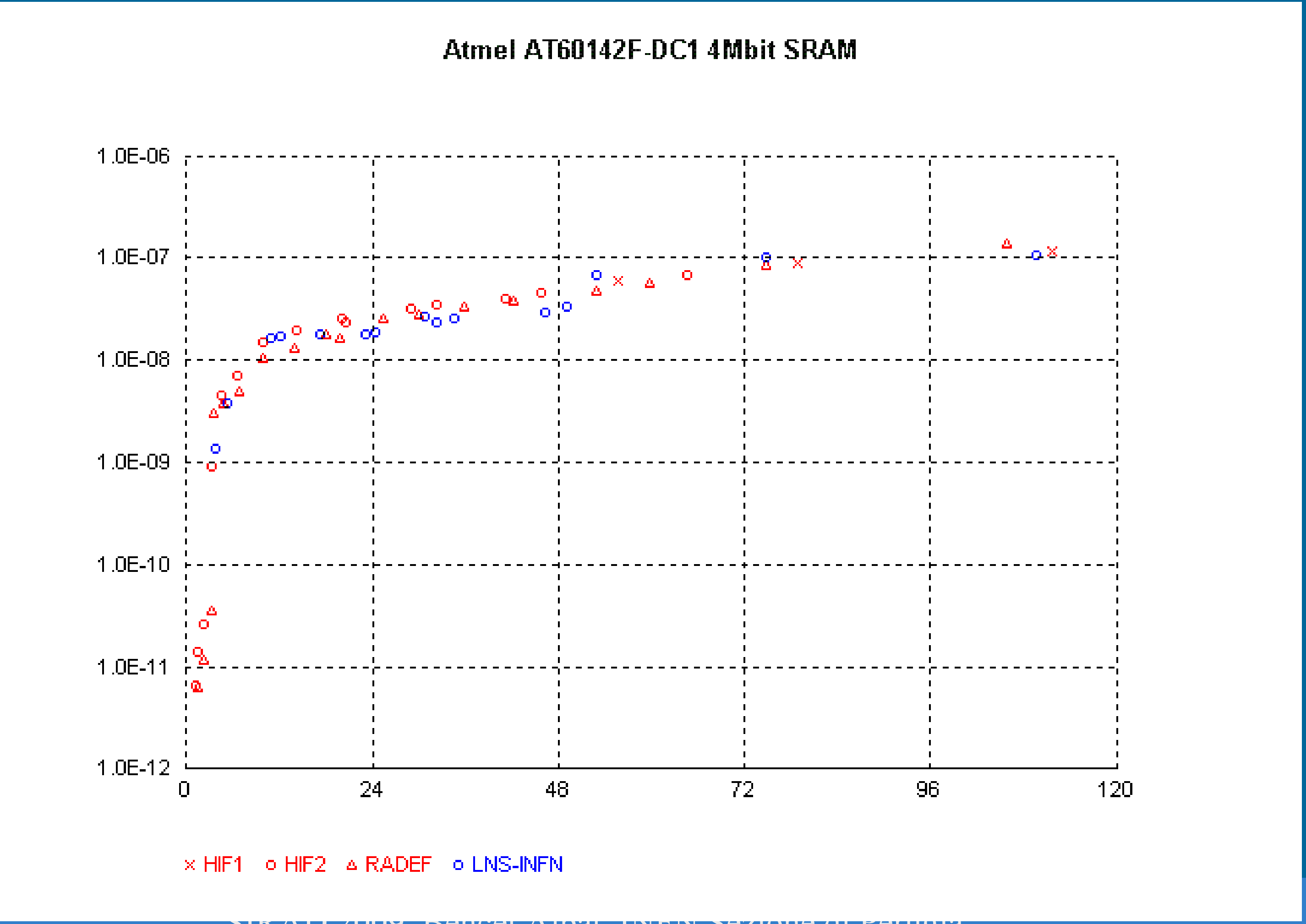


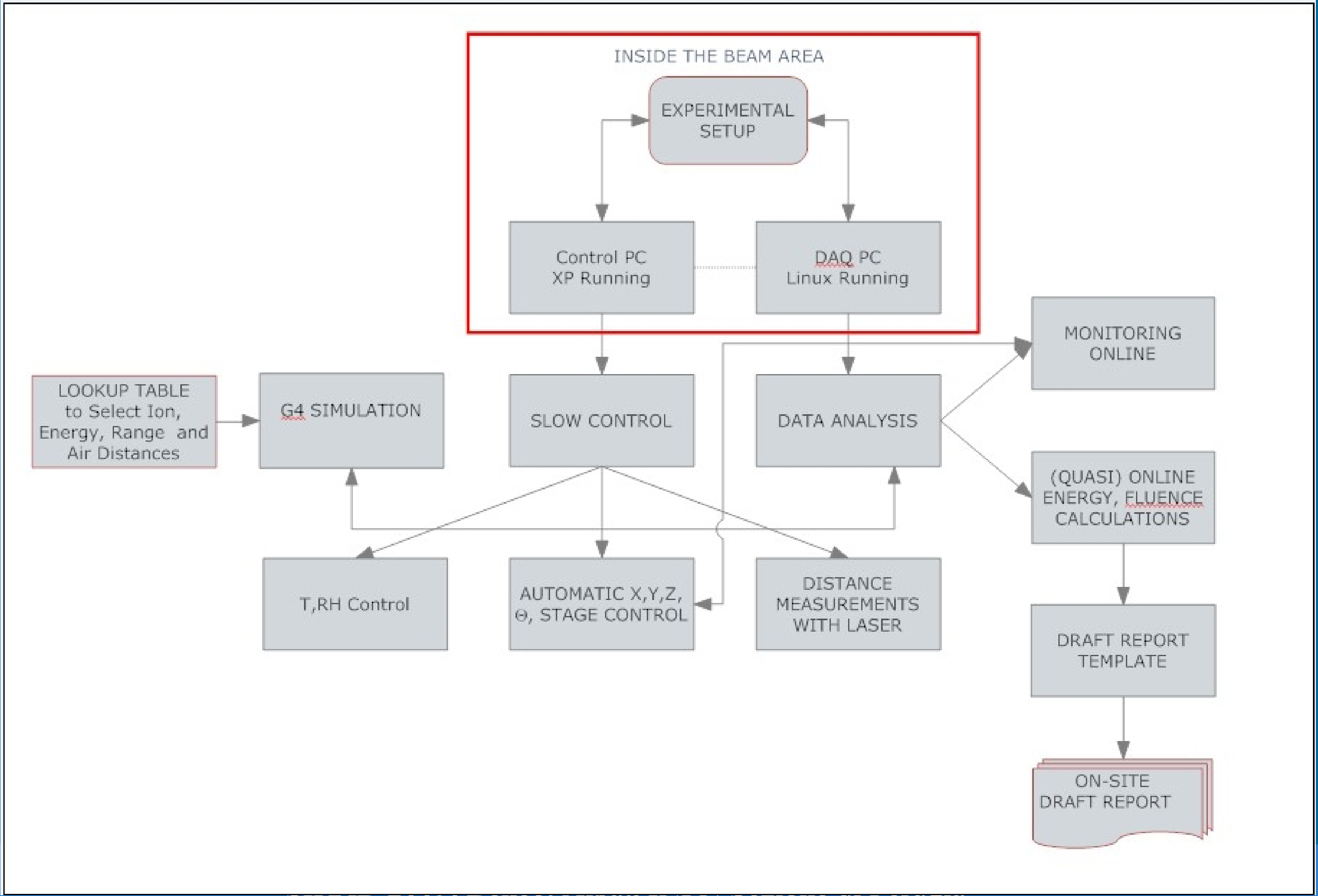
Figure 6. Atmel 4-Mbit SRAM – 8 blocks of 512K x 1.

Reference: R.Harboe-Sorensen, et al., RADECS2005 Proceedings

SEU Monitor and LNS Site



On Site Report Preparation - Process Flow -



Displacement Damage at LNS with SiPMs (1)

- 58 MeV Protons

7.0 Displacement Damage Data (With Protons at LNS)

The Table 1 summarizes all relevant quantities, both measured and calculated, for each irradiation step. The Total Dose are calculated as

$$\text{Dose (Rad(Si))} = \text{Let (Si)*Fluence*}1.610^{-5}.$$

Session Number	Date (dd(mm/yy)	Start Time	Stop Time	Measured pps	Spot Size (cm2)) (FWHM: 0,74*0.56 cm2	Effective Duration (mins)	Measured Fluence (p/cm2) incl. 15% ThinScin ineff.	Total Dose (Rad) (Si)	Total Dose Gy(Si)	Dose Rate (Rad/s)
1	20/05/08	16.40	17.05	4,881E+05	0,4144	25	**4,822E+09**	**725,26**	7,25	483,51
2	20/05/08	19.10	20.14	5,197E+05	0,4144	64	**1,569E+10**	**2359,37**	23,59	614,42
3	20/05/08	22.21	22.52	5,866E+06	0,4144	31	**4,959E+10**	**7458,91**	74,59	4010,17
4	21/05/08	00.49	01:23	6,676E+06	0,4144	34	**9,569E+10**	**14391,81**	143,92	7054,81
5	21/05/08	22.36	00.10	9,659E+06	0,4144	84	**4,106E+11**	**61761,25**	617,61	12254,22
6	22/05/08	06.36	08.35	9,317E+06	0,4144	119	**7,818E+11**	**117586,26**	1175,86	16468,66
7	22/05/08	16.56	20.03	7,891E+06	0,4144	187	**1,117E+12**	**168043,13**	1680,43	14977,11

Table 2. The relevant measured and calculated parameters are listed.

Displacement Damage at LNS with SiPMs (2)

The I-V histograms for each device are traced below in Figure 7, Figure 8 and Figure 9.

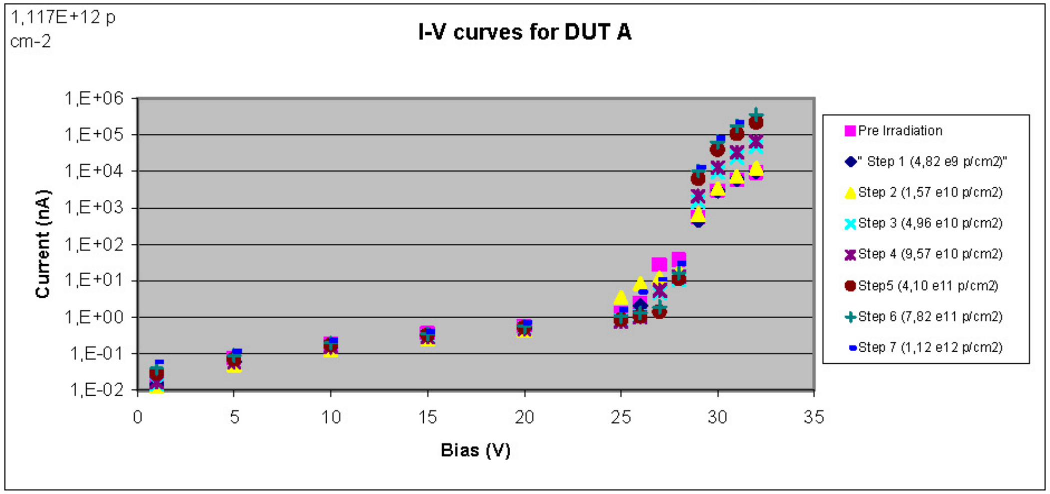


Figure 7 I_V curves for device A prior to irradiation and after each step.

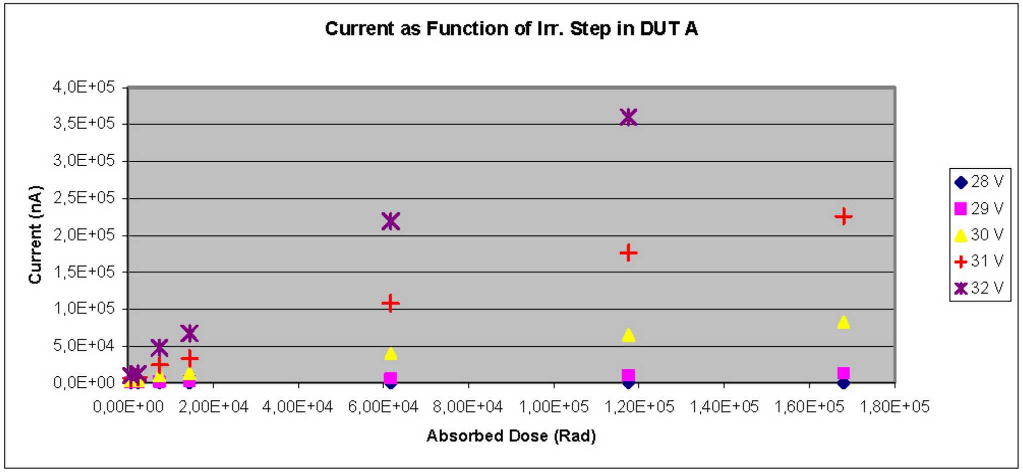
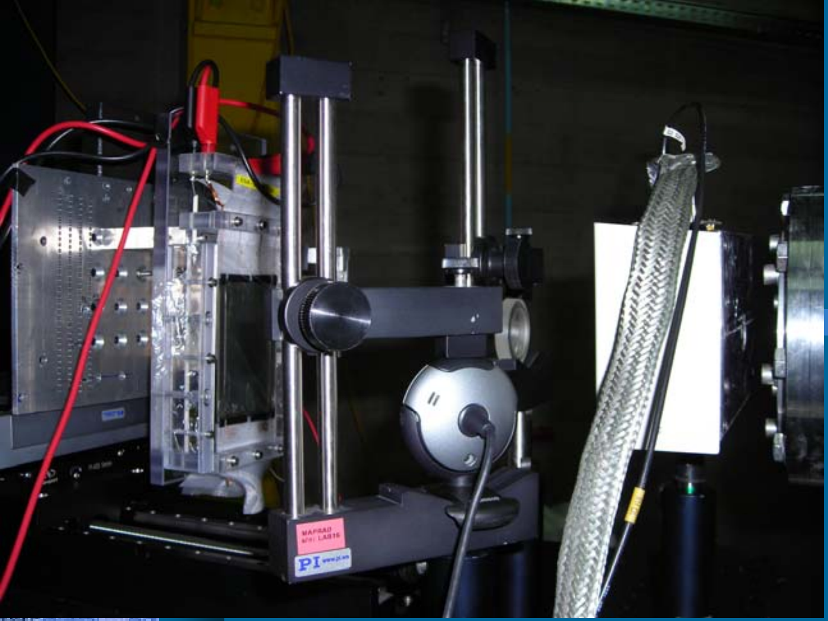
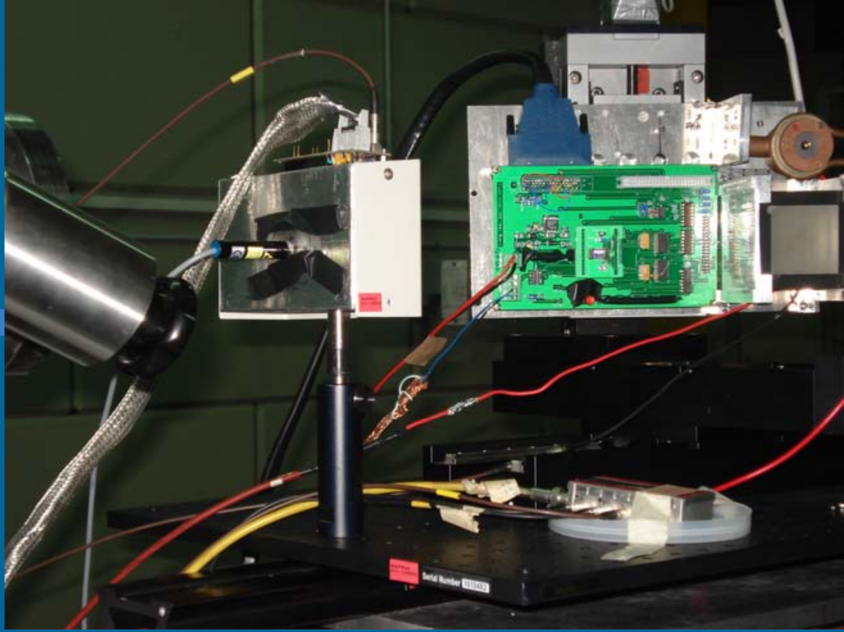


Figure 10 DUT A current as a function of irradiation step at various Bias values around break-down: notice that at 32 V the current was too high for the source meter after step 6.

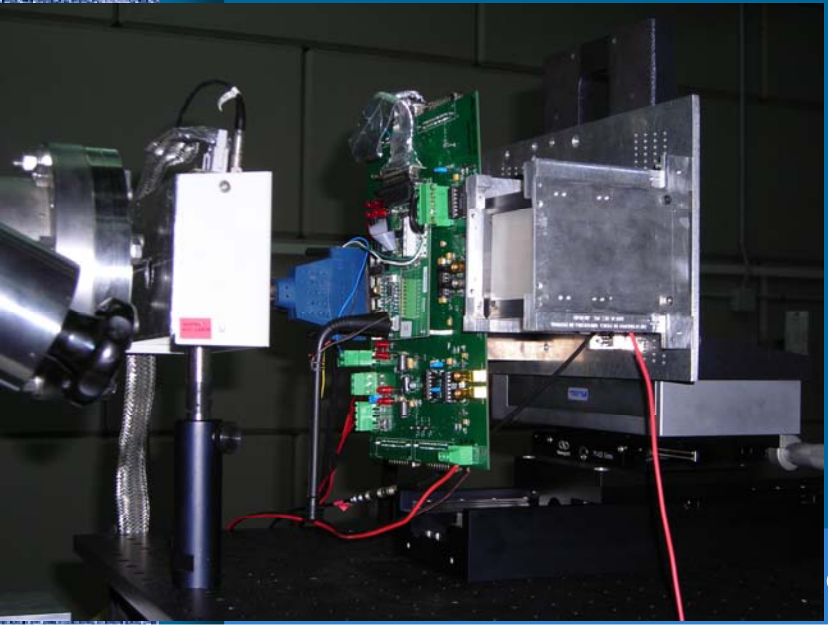
Few Samples DUTs Tested at LNS

Device	Manufacturer	Application	Technology	Power Supply	Data Rate	Data Storage
CC1020	CHIPCON	Transceiver RF 400-940 MHz	CMOS 0.35um	3.3V	153.6kbit	-
AT45DB321CTI	ATMEL	Flash RAM	-	3.3V	40Mbit	4.3MB
EX128TQ100	ACTEL	FPGA	CMOS 0.22um	3.3-5V	-	10k gates
FM20L08	RAMTRON	Ferroelectric RAM	-	3.3V	33MHz	1Mbit
PIC 18F8680	MICROCHIP	Microcontroller	-	5V	40MHz	64kb





- LNS SEE Test Sessions (Nov-Dic 2006)



SEU Test Flow Diagram, XSection vs LET (ions/laser)